Small Business Innovation Research/Small Business Tech Transfer

Ceramic Matrix Composite Environmental Barrier Coating Durability Model, Phase II

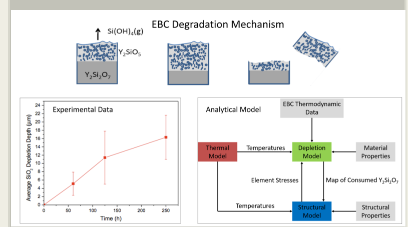
Completed Technology Project (2016 - 2020)

Project Introduction

As the power density of advanced engines increases, the need for new materials that are capable of higher operating temperatures, such as ceramic matrix composites (CMCs), is critical for turbine hot-section static and rotating components. Such advanced materials have demonstrated the promise to significantly increase the engine temperature capability relative to conventional super alloy metallic blades. They also show the potential to enable longer life, reduced emissions, growth margin, reduced weight and increased performance relative to super alloy blade materials. MR&D is proposing to perform a combined analytical and experimental program to develop a durability model for CMC Environmental Barrier Coatings (EBC). EBCs are required for CMCs in turbine exhaust environments because of the presence of high temperature water. The EBC protects the CMC and significantly slows recession. However, the durability of these materials is not well understood making life prediction very challenging. This program seeks to enhance the durability model developed in Phase I to accurately evaluate the life of the EBC for a CMC turbine blade helping to facilitate their inclusion in future engine designs. This goal will be accomplished by grounding the model with experimental tests, which will provide both fundamental properties of the EBC system and a realistic simulation of the engine environment. The engine simulation tests will provide a way for MR&D to validate the model.

Anticipated Benefits

NASA Glenn has been directly involved in the effort to bring CMC materials to turbine hot section components. The NASA Ultra Efficient Engine Technology program (UEET) was focused on driving the next generation of turbine engine technology. One of the major thrusts is the development and demonstration of advanced high-temperature materials which are capable of surviving the extreme environments of turbine combustion and exhaust. More recently, the NASA CLEEN and NextGen programs aim to improve aircraft propulsion efficiency. A major thrust is to demonstrate that advanced high-temperature materials can survive the environment of turbine combustion and exhaust. These materials enable higher engine temperatures directly improving efficiency while reducing cooling hardware. NASA Glenn Research Center has been involved with in the development of SiC/SiC for aero-turbine vanes and blades for a significant period of time. Recent efforts include those aimed at investigating the advantages and disadvantages of SiC/SiC vanes and blades. NASA Glenn has also conducted research on environmental barrier coatings for SiC/SiC turbine engine components. The research conducted as part of this Phase II program is directly applicable to the NASA Glenn efforts noted and can be used to complement those development efforts. Similarly, the results from the NASA work could help to improve the materials and tools being developed in this program.In the commercial sector, the Rolls Royce Trent 1000 and Trent XWB engines are being developed for the Boeing 787 and Airbus A350 XWB aircraft, respectively. There are currently 1031 Boeing 787s

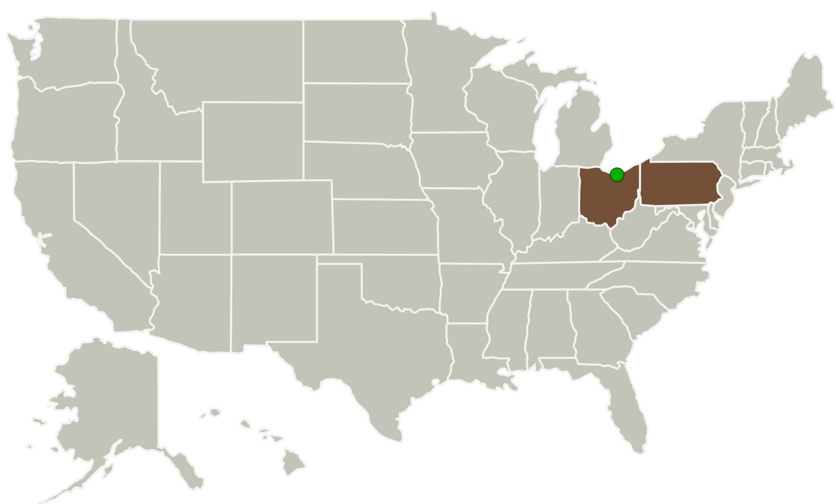


Ceramic Matrix Composite Environmental Barrier Coating Durability Model, Phase II

Table of Contents

on order and 812 Airbus A350 XWBs on order. The Trent 1000 was the launch engine for the Boeing 787. These are large markets where the benefit of this technology will have a lasting impact on efficiency and cost. By working closely with Rolls Royce during the early stages of this development program, MR&D has ensured that the resulting products will meet the requirements of future customers. Through its own investment in EBCs, Rolls Royce has demonstrated a serious interest in this technology and, as demonstrated above, have a sizable market for its application. The aerospace industry is not the only potential beneficiary of this technology. The Department of Energy (DOE) is working hard to improve the efficiency of power generators. Just as with aircraft engines, power turbines' efficiency improves with higher operating temperatures. As an example, current turbines operate at 2600°F, which provided a large improvement in efficiency over earlier models operating at 2300°F. CMC turbine blades and vanes will allow even higher temperature operation and is a topic which the DOE is currently investigating.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Materials Research and Design, Inc.	Lead Organization	Industry	Wayne, Pennsylvania
Glenn Research Center(GRC)	Supporting Organization	NASA Center	Cleveland, Ohio

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Materials Research and Design, Inc.

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

Carlos Torrez

Project Managers:

Michael J Kulis
Matthew C Deans

Principal Investigator:

Michael Dion

Ceramic Matrix Composite Environmental Barrier Coating Durability Model, Phase II

Completed Technology Project (2016 - 2020)

Primary U.S. Work Locations	
Ohio	Pennsylvania

Project Transitions

September 2016: Project Start

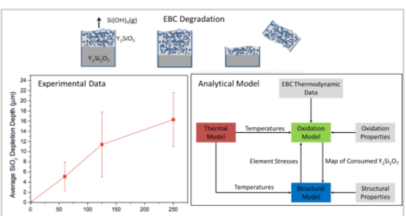
August 2020: Closed out

Closeout Documentation:
- Final Summary Chart PDF*(https://techport.nasa.gov/file/140796)*

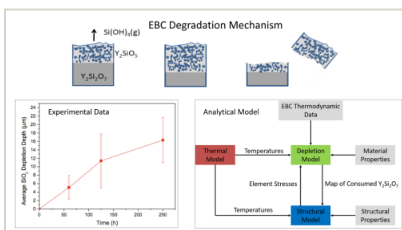
August 2020: Closed out

Closeout Documentation:
- Final Summary Chart*(https://techport.nasa.gov/file/140795)*

Images



Briefing Chart Image
Ceramic Matrix Composite Environmental Barrier Coating Durability Model, Phase II
(https://techport.nasa.gov/image/132308)



Final Summary Chart Image
Ceramic Matrix Composite Environmental Barrier Coating Durability Model, Phase II
(https://techport.nasa.gov/image/133310)

Technology Maturity (TRL)

Start: **3**
Current: **4**
Estimated End: **4**

1	2	3	4	5	6	7	8	9
Applied Research			Development			Demo & Test		

Target Destinations

The Sun, Earth, The Moon, Mars, Others Inside the Solar System, Outside the Solar System